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SALVAGING RAIN-DAMAGED PRUNES

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A. RAIN DAMAGE, 1918

1. *The September Rains.*—The heavy and unexpected rains of September came at a time when most of the prune crop was either on trays or still in the orchard. Only a small part of the crop had been dried and placed under cover. The storm began September 12, about dusk, and rain fell almost daily for over two weeks. For about three weeks, following September 12, the weather was cloudy, moist, and warm, unfavorable to drying, and very favorable to the development of mold and fermentation. A large part of the crop was a complete loss. Some of the fruit was finally dried but sold at a reduced price because of inferior quality. A relatively small portion of the crop made first grade dried fruit.

As most growers expected the storm to last but a day or two, little was done during the first few days that would protect the prunes through a long period of wet weather. Most of the prunes were finally stacked, but many were wet before stacking. After four days of rainy weather, many of the prunes had become so moldy that little could be done to save them in the short time available before they spoiled completely. To make conditions worse, labor was very scarce and often of inferior quality.

In spite of these adverse conditions, certain dry-yards were able to save a considerable portion of their fruit by use of the methods to be described later.

2. *Extent of the Damage.*—It is difficult to estimate accurately at this time (January 1, 1919) the total loss to the prune industry, because all of the salable fruit has not yet reached the packers and considerable fruit in packing houses has been condemned by the pure food authorities. Most of the fruit in the orchards at the time of the rain was lost and at least 25 per cent of that in the yards was a total loss. These two items represent about 50 per cent of the crop. The

money loss was greater than this because the remaining 50 per cent brought a lower price than would normally be the case, and the cost of production was increased because of labor and material spent in attempts at salvage.

It is probable that the money loss would represent 60 per cent of the value of the entire crop or at least $5,000,000.

3. *Nature of the Damage.*—Most of the damage was caused by mold growth and yeast fermentation. Injury resulted also from splitting of fruit in the orchard and softening of the fruit both in the orchard and on the trays.

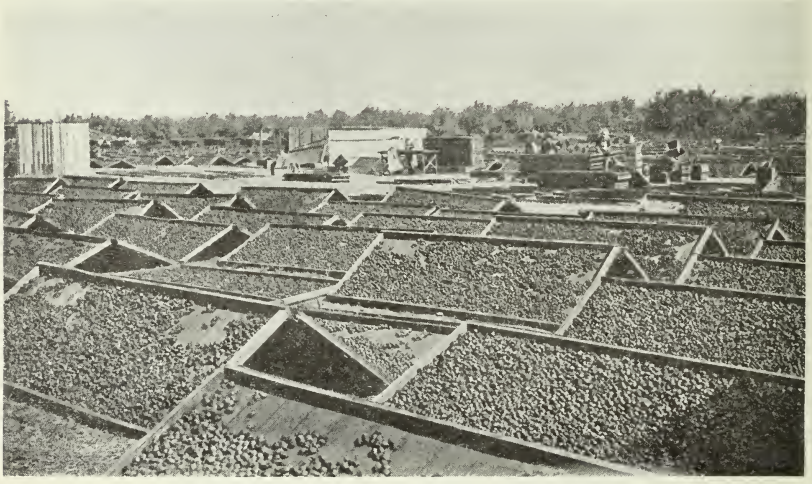

Fig. 1.—A Santa Clara Valley dry-yard shortly after the rain. Trays are elevated at an angle to keep them off the wet ground.

(*a*) Molding: Three days after the rain began, mold growth was visible on much of the fruit on the trays. Within a week it was difficult to find any untreated fruit free from mold.

Four forms of mold predominated, although many other types were present. A greenish brown mold grew on the exposed surfaces of the fruit on the trays. To the eye it appeared as a short "fuzzy" and often powdery growth. The microscope showed it to be an *Alternaria.* It did not affect the flavor of the fruit but seemed to cause loss of sugar.

A black pustule-like growth of "sooty mold" was very common. It was found to consist of a mixture of cells and filaments in which large yeast-like cells predominated. The flavor of the prunes seemed

little injured by its presence, but the skin of the fruit was softened and the appearance badly damaged.

A cottony growth of white mold filaments often covered all of the fruit on the trays and filled the spaces between the fruit. It was found to be a form of *Mucor,* which did not noticeably affect the flavor of the fruit. Its appearance is shown in figure 2.

The most damaging mold consisted of ordinary green *Pencillium.* It grew most commonly on the under side and edges of the fruit in contact with the tray and also on the upper surface of wet trays. The skin of the fruit was softened rapidly, separated from the fruit, and

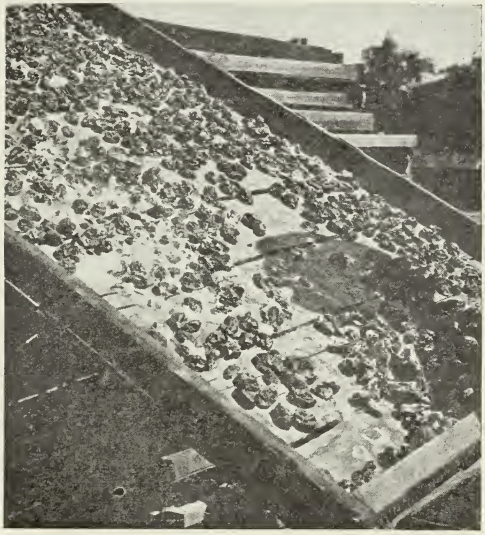

Fig. 2.—*Mucor* mold growing on wet prunes. September 20, 1918.

stuck to the trays when the mold had been growing several days. It penetrated the fruit and imparted a disgusting moldy odor and flavor. Trays were badly injured and must be thoroughly cleaned before being used another season.

Even after thorough processing, fruit that has become very moldy on the trays can be recognized by the microscope. To examine the fruit for mold, scrape a little of the surface with a knife, mount the material obtained on a slide and examine with the microscope.

(*b*) Fermentation: Fermentation of the fruit became evident about three days after the start of mold growth. Most of the fruit that had not received preventive treatment was by September 20 in active fermentation. Fermentation was caused by yeast which appar-

ently first developed around the pit. It probably gained entrance through the stem end and in a very short time the whole flesh of the fruit became filled with yeast cells. The fruit swelled through the formation of carbon dioxide gas and developed a strong alcoholic flavor. The fruit lost a great deal of sugar by this fermentation. The alcohol evaporated as the fruit became dry. The presence of gas pockets around the pit and in the flesh of the dried fruit is the most visible evidence in the dried fruit that fermentation has taken place. Prunes dried after severe alcoholic fermentation are practically nothing but "skin and pit"; very little sugar is left. Such fruit is light and will float in water if tested soon after drying.

The flesh of fermented prunes examined under the microscope shows large numbers of yeast cells. This is a sure method of differentiating between sound and fermented fruit. When fermentation does not progress very far, the fruit contains almost as much sugar as sound fruit and when cooked is probably just as wholesome as fruit which has not been attacked by yeast.

(*c*) Vinegar Fly Larvae: The soft fermenting fruit attracted vinegar flies. The eggs of these flies were deposited on the fruit and within about ten days after the beginning of the rain, much of the fruit was infested with their maggots (larvae). Such fruit, of course, became worthless.

(*d*) Mechanical Damage to Fruit on Trays: The rain softened the fruit very badly in many cases so that it flattened or stuck to the trays. Such fruit had to be removed by hand sorting after drying.

It was also claimed that fruit exposed to the rains for several days lost a great deal of sugar by leaching. It was difficult, however, to ascertain how much sugar was lost in this way because such fruit usually fermented or molded.

(*e*) Damage to Fruit in Orchard: For four or five days after the beginning of the storm, the fruit on the trees and ground appeared sound, although a great deal of it had cracked. Within a week much of this fruit was severely attacked with a greenish brown mold (*Alternaria*) and common green *penicillium* mold. Besides this very evident injury, the fruit became excessively soft and "mushed" down badly in dipping. Attempts to dry it without dipping were not satisfactory because of the slowness of drying and the development of large numbers of "frogs."

Because the orchard ground was so soft after the rain and because the fruit in the yards demanded so much attention, much of the fruit in the orchards became worthless before the growers had an opportunity to gather it. On September 18, the fruit on the trees and on

the ground was examined and from 25 to 50 per cent was found to be sound; the remaining 75 or 50 per cent was cracked badly and more or less moldy. Practically all of the fruit was too soft to be handled satisfactorily by the usual methods. On September 21, orchards in the same locality were examined and not over 5 per cent of the fruit was found to be whole and sound.

B. TREATMENT OF FRUIT WITH ORDINARY DRY-YARD EQUIPMENT

1. *Stacking the Trays.*—Most fruit in the dry-yards was stacked as soon as possible after the rain started, but much of it became wet before stacking and a great deal more became wet in the stack because the rain was so severe and so prolonged. The rain was too heavy and prolonged for stacking to accomplish much good.

2. *Turning Fruit on Trays.*—After a light rain, molding can be checked and drying facilitated by turning or stirring the fruit on the trays. This treatment was of very little benefit in September, because of the moist atmosphere and frequent rains.

3. *Elevating Trays above Ground.*—Wet ground tends to impede the drying of fruit on trays in contact with the ground. The trays were raised from the ground in most yards as shown in figure 1, but this practice did not materially assist drying because of the long-continued unfavorable weather.

4. *Transfer to Dry Trays.*—Where empty dry trays were available, the transfer of wet fruit to these was an important factor in saving some fruit that was already at least two-thirds dried. Most yards had no extra trays.

5. *Dipping Fruit from Trays.*—Mold that has started to develop on prunes can be destroyed by dipping the fruit in boiling water or a hot dilute solution of lye or salt. This method was given a thorough trial by several yards, but the prolonged period of wet weather permitted mold to develop again after dipping. Moldy trays reinfected the fruit and as a result, dipping of the fruit alone gave no positive results.

6. *Sulfuring.*—No single method of treating the wet fruit proved more effective than that of exposing it for two to three hours to the fumes of burning sulfur. The University recommended this method strongly. But even before its recommendation was given, many yards had already undertaken the sulfuring of as much of the fruit as their sulfuring house capacity permitted.

Two to three hours' sulfuring killed all mold and yeast present in or on the fruit and impregnated the fruit with sufficient sulfurous

acid to prevent growth of mold or yeast, which might infect the fruit later. The sulfured fruit dried much more rapidly than untreated fruit.

The main disadvantages of the sulfuring of the fruit were the production of a lighter color, and of a tart or "plum" taste in the finished product. Where the fruit was two-thirds dry or more, the bleaching effect of the sulfur was negligible; where freshly dipped

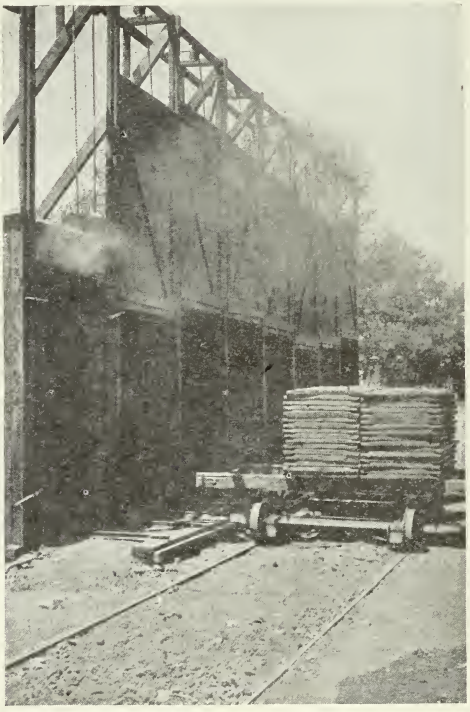

Fig. 3.—Common type of sulfur house in use in Santa Clara Valley.

prunes were sulfured, the fruit after drying belonged to the "ruby" prune class. The dry-yards expect to receive a slightly lower price for sulfured fruit than for perfect unsulfured fruit, but any profitable return is to be preferred to a total loss. The dry-yards did not possess adequate equipment and did not start their operations in time to treat any appreciable percentage of the crop.

Should this emergency ever arise again, it is advised with all emphasis that the dry-yards utilize their sulfuring houses to the utmost and construct with all possible speed temporary sulfuring

hoods. These can be built very quickly by local mills, lumber yards, and carpenters. All such should be enlisted to turn out sulfur hoods in quantity. Professor Bioletti has described such a hood for raisin dry-yards which could be modified for use with prunes. Specifications for this hood are given in a recent circular. It is made to be placed over two stacks of 2×3 feet raisin trays and sulfur is burned in a can or pan between the stacks and under the hood.

For 8×3 feet trays, a suitable hood would be 9½ feet long by 40 inches wide by 5 feet high. It would be built of a light, braced frame covered with light roofing paper; i.e., rubberoid roofing or building paper.* It would be fitted with handles at each bottom corner by which two men could lift it and set it down over the trays. It is 1½ feet longer than the trays and in this space the sulfur may be burned.

It would even be a wise plan to have a number of these sulfur hoods made up and stored in a convenient place, as an insurance against rain damage in future years. Their cost is small; each would not cost more than five dollars and would be capable of saving over one and a half tons of fruit per twenty-four hours. *No better investment for a prune dry-yard can be made.*

Mr. F. R. Shafter, of Stevens Creek Road, San Jose, began sulfuring his fruit the third day after the rain had started. He exposed the fruit in most cases for about three hours to the fumes of the sulfur and then handled it in the yard in the usual way. He also sulfured practically all fresh fruit dipped after the rain. Fruit sulfured after it had become moldy or fermented did not develop further mold or yeast, but of course the damage done before the fruit was sulfured was not removed. The sulfured and unsulfured fruit was examined on November 29. The color of the sulfured fruit ranged from nearly black to "ruby," but was considerably lighter in color than the untreated fruit. Most of it was free from mold and yeast, and clean in flavor. Mr. Shafter was well pleased with the results and would repeat the treatment in another such emergency. He sold the fruit at a profitable price.

Others who obtained good results from sulfuring were F. Holmes, San Jose; A. E. Graham, of J. H. Flickinger Company, of San Jose; Warren Hyde, Cupertino; and William Fisher, Union Station, Napa County. Mr. Hyde redipped his fruit before sulfuring. He found that sulfuring checked all mold and yeast growth and did not lighten the color of fruit which was half or two-thirds dry when sulfured.

* Professor Bioletti recommends covering the frame first with burlap to give rigidity. Then this is covered with building paper to make the hood fume-tight.

7. *Treatment of Fruit from the Orchard.*—As already stated, the fruit on the trees and ground became soft after the rain. Attempts to dry this fruit without dipping were not satisfactory and dipping resulted in much breaking or "mushing" of the fruit. Fruit which was not sulfured molded in most cases.

Therefore, the most practical method of handling the fruit is to gather only the best fruit in the orchard and to leave the excessively soft and badly damaged fruit. This selected fruit can then be given a short dip and spread carefully on trays. To prevent development of mold or yeast, it should be sulfured for two hours and then dried in the usual manner.

The experiences of many dry-yards during the past season have shown this method to be satisfactory.

8. *General Application of Evaporators to the Drying of Damaged Prunes.*—Evaporators may be used in one of several ways. The wet fruit may be dried in the evaporator until dry enough for packing. If time is available, this is probably the best procedure.

Or, the fruit and trays may be dried a few hours in the evaporator to remove surface moisture only. Drying would then be completed in the sun.

It is also feasible to sulfur lightly the fruit which can not be put in the evaporator at once and this fruit can then be dried later. This was done by William Fisher of Union Station, Napa County, with excellent results.

9. *Sorting Damaged Fruit.*—Most of the fruit was left on the trays and allowed to dry regardless of mold or fermentation. Much of this fruit was of fair quality when dry, but was mixed with a large percentage of moldy or fermented fruit and "slabs." Some dry-yards attempted to hand sort this material. It is doubtful whether they were repaid for the expense and trouble incurred.

It was found by experiments at the University that badly fermented fruit would float on water and that the sound fruit would sink. This gave an easy method of separation. The use of a 5 per cent salt solution (6½ ounces of salt per gallon of water) gave a much sharper separation than water. A 10 per cent solution of glucose, corn syrup, or sugar gave as good a separation as a 5 per cent brine and in addition gave a finished gloss to the fruit.

A typical lot of damaged fruit yielded 40 per cent fermented material and 60 per cent sound fruit by this method. The "slabs" sank with the sound fruit, but were easily recognized and separated in subsequent hand sorting.

The ordinary dipping basket and dipping tank could be used. The fermented prunes would rise to the surface and could be skimmed off; the sound fruit would remain in the basket and could be dumped from the basket on to clean dry trays where the surface of the prunes could be dried before delivery to the packing house. This method does not give good results with fruit which has been held a month or more after it is dry.

C. UTILIZATION OF BADLY DAMAGED PRUNES

1. *Value for Alcohol.*—Analyses and fermentation tests made by Mrs. Jean Christie in the Zymology Laboratory showed that one ton of damaged prunes could be made to yield twenty to fifty gallons of 95 per cent alcohol. At 50 cents per gallon, this has a value of $10 to $25 per ton of partially dried fruit as received. This is not a large money return.

Alcohol distilleries use cheap beet molasses and were not interested in the possible utilization of prunes for alcohol for powder manufacture when prospects of the end of the war came.

2. *Value for Vinegar.*—On the basis of a distilled vinegar of 10 per cent acetic acid content, one ton of the damaged friut would yield 200 to 500 gallons of vinegar. At 15 cents per gallon, this would bring a return of $30 to $75 per ton of fruit. The demand for vinegar is limited and it is therefore doubtful if any appreciable quantities of fruit could be used in this way.

3. *Syrup.*—A palatable, clear, dark amber syrup was made from the damaged fruit on a laboratory scale. Many different methods were tested, but the following was found most satisfactory.

The prunes were heated to between 180° and 190° F. with twice their weight of water. The mixture after heating was left twenty-four hours. The fruit was then placed in a cider press between heavy press cloths and subjected to hydraulic pressure of about 500 pounds per square inch. The resulting juice was analyzed for its acid content and enough precipitated chalk added to reduce the acidity to .2 per cent. To the juice was then added 2 per cent by weight of "Filter-Cel" to aid in filtration. The treated juice filtered fairly well.

The clear juice so obtained contained about 15 per cent of sugar (15 per cent Balling test) and .2 per cent acid. It was then concentrated in a vacuum kettle to from 65 per cent to 70 per cent Balling.

One ton of the prunes of the sort used in the experiment would give by this method about fifty gallons of syrup. At 75 cents per gallon, its value would be about $35.

4. *Pits.*—The prunes examined contained from 13 per cent to 20 per cent of pits. The kernels were equal to 18 per cent of the weight of the pits. The kernels were rich in oil and bitter almond oil. It is probable that the pits would afford a fairly valuable by-product. They can be separated from the pulp by a machine similar to a tomato pulper.

5. *Canning.*—The badly damaged prunes are not suitable for canning because the State Food and Drug Laboratory does not consider them fit for food as prunes. The fruit can, however, be carefully sorted and the better material canned in a light sugar syrup. The fruit may be cooked before canning or the cans may be filled about half full, syrup added, and the fruit cooked in the sealed can. This method should also form a good outlet for small prunes in normal years.

6. *Jams and Butters.*—These products were suggested by several manufacturers and others. Badly damaged fruit can not be used for these products, even if the products can be made to possess a pleasing flavor, because the molds and yeasts will be present in the finished product and will readily be found by use of the microscope. The State Board of Health would therefore rightly condemn all products of this sort unless they were made from sound clean fruit.

7. *Value for Hog Feed.*—Under Professor Jaffa's direction, the feeding of damaged prunes for garbage fed hogs was tested by W. L. Bohannon. Excellent results were obtained by using 85 per cent garbage and 15 per cent prunes. The hogs ate the prune flesh and then cracked the pits to obtain the kernels. Gains in weight were rapid. Santa Clara Valley hog feeders also obtained good results in the way of gains but found that the hogs must be finished on grain feed to avoid disagreeable color and flavor in the pork, which result if large proportions of prunes are fed. Where they form only 15 per cent of the ration, this defect would probably not result.

SUMMARY

1. The September rains of 1918 destroyed at least 50 per cent of the value of the prune crop and caused a loss of probably not less than $5,000,000.

2. Most of this damage was caused by mold growth and yeast fermentation during the long period of warm damp weather following the rain.

3. Usual methods of handling the fruit by stacking the trays, turning the fruit on the trays, redipping, etc., failed to check the mold and yeast in most cases.

4. Sulfuring the fruit on the trays for two to three hours, as is done with apricots, checked mold and yeast growth and made it possible to dry the fruit without artificial heat. Fruit dried in this way was salable and of excellent flavor; it was usually lighter in color than fruit dried in the usual way.

5. Fermented dried prunes, if not held too long after drying, may be separated from sound fruit by flotation in water, or, better, in a 5 per cent salt solution or 10 per cent glucose solution. This process simplifies sorting after drying.

6. Analyses of damaged fruit and investigations of its utilization for alcohol, acetic acid, vinegar, and syrup manufacture were made. It was also tested in a practical way as a hog feed by Professor Jaffa. Results were fairly satisfactory, but returns in no case would be very large.

CONCLUSIONS AND RECOMMENDATIONS

1. Exposure of wet prunes to the fumes of burning sulfur for two to three hours is the most simple and effective method of quickly checking molding and fermentation. Sulfuring should not be delayed more than three days after the rain. Every prune dry-yard should have adequate sulfur house capacity for such an emergency as that of September, 1918.

2. Usual methods of handling wet prunes by turning, stacking, etc., are not sufficient under the conditions of the 1918 season. Sulfuring or artificial evaporation are necessary.

3. More evaporators should be built and kept in repair for immediate use.

4. Badly damaged fruit should not be thrown away but should be utilized for hog feed, syrup, or in some other way.

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